

ART. II.—*On a Shell-bed underlying Volcanic Tuff near Warrnambool; with Notes on the Age of the Deposit.*

BY

FREDK. CHAPMAN, A.L.S.,

AND

CHAS. J. GABRIEL.

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*1.—Occurrence of the Shell-bed.*

Whilst on a visit to the Western District in 1912, the writers were informed by Mr. H. J. Hauschildt, of the Warrnambool Agricultural High School, of an interesting occurrence of a bed of shells in the dune-rock exposed at the mouth of the Hopkins River, on the right bank, close to the Boat-sheds. This occurrence seemed worth investigation from the fact that the shell-bed is completely covered by the tuffs of the Tower Hill series, an examination of the organic contents promising to throw some light on the age of the tuffs of the district and the building of the Tower Hill crater.

It is a matter of general knowledge amongst geologists that exposures of shell-beds are frequently found underlying the newer volcanic in this locality,<sup>1</sup> but so far as we are aware, no detailed examination of the fauna has been carried out. Hence, as a result of our visit these notes have been prepared, although owing to more pressing work they have been unavoidably delayed.

*2.—Condition of the Shell-bed.*

The stratum consists of a closely packed shelly and calcareous sandy deposit. The material is not consolidated by deposition from solution or by any secondary mineralisation, for it can be readily

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<sup>1</sup> Brough Smyth in his paper "On the Extinct Volcanoes of Victoria, Australia" (Quart. Journ. Geol. Soc. Lond., vol. xiv., 1858, p. 227), quotes a letter of A. R. C. Selwyn's dated August 11th, 1857, in which he says "Tower Hill is certainly the most recent volcanic vent I have yet seen. It appears, at least during its later eruptions, to have emitted vast quantities of ashes and scoriae; these are seen near Warrnambool, resting on beds of shell, sand and earthy limestone, containing numbers of living littoral species of mollusca."

broken up in the fingers and the sand is loose enough to be scraped out of the interior of the shells with the finger-nail.

The mollusca are in some cases polished, as though by wind action, and this also holds good for the foraminiferal shells. As a rule, however, the molluscan shells are dull and slightly weathered without being greatly worn. The finer siftings consist of abraded and polished sand-grains consisting of chips of the larger shells, echinoid fragments and foraminiferal tests, thus indicating a certain amount of aeolian action or sand-dune conditions.

### 3.—Organic Contents.

#### Order FORAMINIFERA.

##### *Rotalia beccarii*, Linné sp.

*Nautilus beccarii*, Linné, 1767, Syst. Nat., 12th ed., p. 1162; 1788, *ibid*, 13th (Gmelin's) ed., p. 3370, No. 4.

*Rotalia beccarii*, L. sp., Chapman, 1907, Journ. Quekett Micr. Club, ser. 2, vol. X., p. 139.

This widely distributed and even cosmopolitan form is represented here by a fairly large series. Its presence indicates a shallow-water or shore-line deposit with estuarine influence. As a fossil it is commonly found in Victoria in similar shallow water facies, from the Kalimnan (Lower Pliocene) upwards, but there is also one record of the species from the earlier series, the Janjukian, of Waurn Ponds, by Mr. Howchin. That authority has also recorded *R. beccarii* from the Kalimnan of Nor<sup>2</sup>-West Bend, Murray River; from the W. end of Torrens Lake, Adelaide; and from the upper beds of Muddy Creek. Howchin also found it in the Upper Pliocene of Dry Creek, South Australia, and in the Post-tertiary of Port Adelaide.<sup>1</sup> One of us has also noted *R. beccarii* in the Mallee bores from all three horizons, of Janjukian, Kalimnan and Werrikooian.<sup>2</sup>

The condition of the tests shows this species to have lived in a congenial habitat, the estuarine influence having been supplied by the Hopkins or equivalent stream, probably before its mature river bed had been disturbed by the local uplifts due to volcanic activity in the western district.

1 See Rep. Austr. Assoc. Adv. Sci., Adelaide, 1893, pp. 351, 352.

2 Proc. Roy. Soc. Victoria, vol. xxvii. (n.s.), pt. i., 1914, p. 60.

## Class PELECYPODA.

## Fam. LEPTONIDAE.

Genus *Erycina*, Lamarck.*Erycina helmsi*, Hedley.

*Erycina helmsi*, Hedley, 1915. Proc. Linn. Soc. N. S. Wales, vol. XXXIX., pt. IV., p. 701, pl. LXXX., figs. 37-39.

This species was first described from the *Zostera*-beds at Deewhy Lagoon, N. S. Wales. In Victoria it has occurred at Port Melbourne, Corio Bay, Altona Bay, Port Albert and Lakes Entrance. It is fairly abundant in the Warrnambool fossil deposit.

Owing to the apparently slight difference between the fossils and the figured type we have conferred with Mr. Hedley as to their specific agreement, and he has kindly examined them, together with living-specimens from Lakes Entrance and his own type specimen, and notes a possible difference in the fossils in "that the long end is more pointed in the fossil and more rounded in the recent." We find, however, every degree of variation in this respect, within small limitations, and there seems hardly enough evidence to warrant even a varietal distinction. The finely contused or pitted surface is as well marked on the fossil specimens as on the recent.

## Fam. VENERIDAE.

Genus *Marcia*, H. and A. Adams.*Marcia nitida*, Quoy and Gaimard sp.

*Venus nitida*, Quoy and Gaimard, 1835, Voyage Astrolabe, Zool., vol. III., p. 529, pl. LXXXIV., figs. 13, 15 (in the text figs. 13, 14 in error).

*Chione fumigata*, Sowerby sp., Pritchard and Gatliff, 1903, Proc. R. Soc. Vict., vol. XVI. (N.S.), pt. I., p. 123.

*Chione nitida*, Q. and G. sp., Hedley, 1904, Proc. Linn. Soc. N.S. Wales, vol. XXXIX., p. 194. Pritchard and Gatliff, 1906, Proc. R. Soc. Vict., vol. XVIII. (N.S.), pt. II., p. 67.

*Marcia nitida*, Q. and G. sp., Hedley, 1917, Proc. Linn. Soc. N.S. Wales, vol. XLI., p. 691, pl. XLVI., figs. 2, 3.

The generic name of this shell, more familiarly known as *Chione* or *Tapes fumigatus*, has lately been the subject of discussion by Messrs. Dall and Jukes-Browne, and their argument is strongly in

favour of separating this and similar forms with smooth shells and uncrenulated margins, under the generic term *Marcia*.<sup>1</sup>

Practically all the valves of this species found in the fossil bed are deeper than in the living form, although occasionally one may meet with similar shells of recent origin.

This species was fairly common.

Fam. TELLINIDAE.

Genus *Tellina*, Linne.

*Tellina deltoidalis*, Lamarck.

*Tellina deltoidalis*, Lamarck, 1818, Anim. sans Vert., vol. V., p. 532. Pritchard and Gatliff, 1903, Proc. R. Soc. Vict., vol. XVI. (N.S.), pt. I., p. 115. Suter, 1913, Manual of N. Zealand Mollusca, p. 948 (Atlas), pl. LIX., fig. 11.

Several fragments of this common shore-living species occurred in the present deposit.

Fam. PSAMMOBIIDAE.

Genus *Soletellina*, Blainville.

*Soletellina biradiata*, Wood sp.

*Solen biradiata*, Wood, 1815, General Conch, p. 135, pl. XXXIII., fig. 1.

*Soletellina biradiata*, Wood sp., Pritchard and Gatliff, 1903, Proc. R. Soc. Vict., vol. XVI. (N.S.), pt. I., p. 114. Suter, 1913, Manual of N. Zealand Mollusca, p. 1083 (Atlas), pl. LXII., fig. 13.

Numerous specimens of the above species, mostly fragmentary, occur here.

Fam. MACTRIDAE.

Genus *Spisula*, Gray.

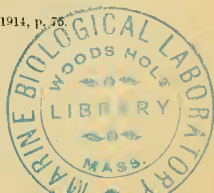
*Spisula trigonella*, Lamarck sp.

*Maetra trigonella*, Lamarck, 1818, Anim. sans Vert., vol. V., p. 479.

*Gnathodon parvum*, Petit, 1853, Journ. de Conch., vol. IV., p. 358, pl. XIII., figs. 9, 10.

<sup>1</sup> Dall. Proc. U. S. Nat. Mus., vol. xxvi., 1903, p. 335.

Jukes-Browne. Proc. Malac. Soc. Lond. vol. viii., 1909, p. 233 vol. x, 1914, p. 76



*Spisula parva*, Petit sp., Pritchard and Gatliff, 1903, Proc. R. Soc. Vict., vol. XVI. (N.S.), pt. I., p. 108.

*Mactra trigonella*, Lam. Lamy, 1914, Bull. Mus. Nat. Hist., p. 205.

*Spisula parva*, Petit sp., Chapman, 1916, Rec. Geol. Surv. Vict., vol. III., pt. 4, p. 402.

*Spisula trigonella*, Lam. sp., Hedley, 1917, Proc. Linn. Soc. N.S. Wales, vol. XLI., p. 692.

Mr. Chas. Hedley has drawn attention to Dr. Lamy's identification of Lamarck's specimens of "*Mactra trigonella*" in the Paris Museum with our well-known *Spisula parva*, Petit sp.

Typical examples of this shell are here moderately common. It is well distributed round the coast, especially on muddy and sandy flats near the mouths of tidal rivers. In the Sorrento bore this species was found at a depth of 489 feet, associated with *Nassa labecula* and *Rotalia beccarii*.

#### Class GASTEROPODA.

##### Fam. CYCLOSTREMATIDAE.

##### Genus *Pseudoliotia*, Tate.

*Pseudoliotia micans*, A. Adams sp.

*Cyclostrema micans*, A. Adams, 1850, Proc. Zool. Soc. Lond., p. 43. Dennant and Kitson, 1903, Rec. Geol. Surv. Vict., vol. I., pt. 2, p. 145.

*Pseudoliotia micans*, A. Adams sp., Pritchard and Gatliff, 1902, Proc. R. Soc. Vict., vol. XIV. (N.S.), pt. II., p. 102.

One small, but typical specimen found.

##### Fam. LITTORINIDAE.

##### Genus *Diala*, A. Adams.

*Diala lauta*, A. Adams.

*Diala lauta*, A. Adams, 1862, Ann. Mag. Nat. Hist., ser. 3, vol. X., p. 298, No. 5. Pritchard and Gatliff, 1902, Proc. R. Soc. Vict., vol. XIV. (N.S.), pt. II., p. 88.

One specimen found.

##### Genus *Tatea*, T. Woods.

*Tatea rufilabris*, A. Adams sp.

*Diala rufilabris*, A. Adams, 1862, Ann. Mag. Nat. Hist., ser. 3, vol. X., p. 298.

*Tatea rufilabris*, A. Adams sp., E. A. Smith, 1882, Journ. Linn. Soc. Lond. Zool., vol. XVI., p. 268, pl. VII., fig. 19. Gatliff, 1905, Victorian Naturalist, vol. XXII., p. 15.

Three typical specimens of this interesting estuarine shell were found.

Genus **Bythinella**, Moquin-Tandon.

*Bythinella nigra*, Quoy and Gaimard sp.

*Paludina nigra*, Quoy and Gaimard, 1834, Voyage Astrolabe, Zool., vol. III., p. 174, pl. LVIII., figs. 9-12.

There appears to be a large and confusing synonymy for this very variable species, and the present writers have under examination evidence which seems to point to the above specific name as the valid one. Some of the confusion has arisen through bad drawing or inconsistent description, and it is hoped that a comparison of the various types involved will finally settle the question. At present the writers are in communication with some European authorities on the subject, the results of which will be made known as soon as possible. Examples of the so-called species, *victoriae*, *legrandi* and *petterdi* are found in this fossil deposit. The varieties occurring in the Pleistocene of Mowbray Swamp, Tasmania,<sup>1</sup> appear to most nearly approach *Bythinella victoriae*, T. Woods, the types of which are in the National Museum, Melbourne.

Fam. CERITHIIDAE.

Genus **Potamides**, Brongniart.

*Potamides australis*, Quoy and Gaimard sp.

*Cerithium australe*, Quoy and Gaimard, 1834, Voyage Astrolabe, Zool., vol. III., p. 131, pl. LV., fig. 7.

*Potamides australis*, Quoy and Gaimard sp., Pritchard and Gatliff, 1900, Proc. R. Soc. Vict., vol. XIII. (N.S.), pt. I., p. 156.

A solitary example of this estuarine shell was found.

Fam. BUCCINIDAE.

Genus **Nassa**, Lamarck.

*Nassa pauperata*, Lamarck sp.

*Buccinum pauperata*, Lamarck, 1822, Anim. sans Vert., vol. VII., p. 278, No. 56.

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<sup>1</sup> Chapman. Mem. Nat. Mus. Melbourne, No. 5, 1914, p. 57.

*Nassa pauperata*, Lam. sp., Pritchard and Gatliff, 1898,  
Proc. R. Soc. Vict., vol. X. (N.S.), pt. II., p. 279.  
Dennant and Kitson, 1903, Rec. Geol. Surv. Vict., vol.  
I., pt. 2, p. 143.

Rather rare.

*Nassa labecula*, A. Adams.

*Nassa labecula*, A. Adams, 1851, Proc. Zool. Soc. Lond., p.  
98. Pritchard and Gatliff, 1903, Proc. R. Soc. Vict.,  
vol. X. (N.S.), pt. II., p. 279.

This is a fairly common shell in the present deposit. It is generally a component of Victorian estuarine faunas of modern date.

#### Fam. AMPHIBOLIDAE.

#### Genus *Salinator*, Hedley.

*Salinator fragilis*, Lamarck sp.

*Ampullaria fragilis*, Lamarck, 1822, Anim. sans Vert., vol.  
VI., pt. II., p. 179.

*Salinator fragilis*, Lam. sp., Hedley, 1900, Proc. Linn. Soc.  
N.S. Wales, vol. XXV., p. 511. Gatliff, 1905, Victorian  
Naturalist, vol. XXII., p. 15.

A single specimen of this estuarine shell was found in the present deposit.

#### Class CRUSTACEA.

#### Fam. CYTHERIDAE.

#### Genus *Cythera*, Müller.

*Cythere crispata*, G. S. Brady.

*Cythere crispata*, G. S. Brady, 1868, Ann. Mag. Nat. Hist.,  
ser. 4, vol. II., p. 221, pl. XIV., figs 14, 15. Idem,  
1880, Rep. Chall., Zool., vol. I., pt. III., Ostracoda, p.  
72, pl. XIV., figs 8a-d. Chapman, 1914, Proc. R. Soc.  
Vict., vol. XXVII. (N.S.), pt. I., p. 33, pl. VI., fig. 9.

The present specimen is a short, broad variety, but possesses sufficient characters to enable us to refer it without hesitation to the above species. In the living condition it occurs on the shores of Great Britain, Norway and the Mediterranean; also at Port Jackson, Booby Island and in Hong Kong Harbour. In all these localities it is a moderately shallow water form. One of us (F.C.)

has lately recorded it from "Endeavour" material from South Australia at 100 fathoms. In the fossil condition it occurs in the northern hemisphere in the Pleistocene of Scotland, Ireland and Norway; whilst in Victoria it has been obtained in much older beds, viz., the Miocene or Janjukian of the Mallee bores.

## Fam. BALANIDAE.

Genus *Balanus*, Lister.*Balanus* sp.

A rostral compartment of a species of *Balanus*, having an obscure rugo-costulate ornament occurs here. It has some resemblance to *Balanus psittacea*, Molina sp., but is not so heavy in structure.

## 4.—Fossil Mollusca from Dennington, near Warrnambool.

These shells occurred at a depth of 8 feet from the surface and underneath volcanic tuff, at Nestles Milk Factory. This locality is about  $1\frac{1}{2}$  miles inland from the present coast-line.

- Arca (Anadara) trapezia*, Deshayes
- Marcia nitida*, Q. and G. sp.
- Tellina deltoidalis*, Lam.
- Soletellina donacioides*, Reeve
- Donax deltoides*, Lam.
- Mactra polita*, Chemnitz
- Spisula trigonella*, Lam. sp.
- Mesodesma elongata*, Deshayes
- Patella ustulata*, Reeve
- Turbo undulatus*, Martyn sp. (operculum)
- Bankivia fasciata*, Menke sp.
- Potamides australis*, Q. and G. sp.
- Cymatium spengleri*, Chemn. sp.
- Nassa jacksoniana*, Q. and G. sp.
- Nassa labecula*, Adams

The above collection was presented to the National Museum by Mr. D. J. Mahony, M.Sc., April 24th, 1912.

From the same locality Mr. H. J. Hauschildt, on Oct. 5th, 1912, presented, amongst other specimens, the following additional species:—*Pecten bifrons*, Lam.; *Mytilus hirsutus*, Lam.; *Venus (Chione) strigosa*, Lam.; and *Purpora succincta*, Martyn sp.



5.—*Holocene Mollusca from Lake Pertobe.*

This deposit probably belongs to a later episode than the shell-beds underlying tuffs. The locality is S. of Warrnambool and quite close to the coast-line.

*Venerupis crenata*, Lam. sp.

*Tellina deltoidalis*, Lam.

*Spisula trigonella*, Lam. sp.

*Soletellina biradiata*, Wood sp.

*Soletellina donacioides*, Reeve

*Monodonta (Austrocochlea) constricta*, Lam. sp.

*Risella melanostoma*, Gmelin sp.

*Potamides australis*, Q. and G. sp.

*Bittium cerithium*, Q. and G. sp.

*Nassa labecula*, Adams.

*Salinator fragilis*, Lam. sp.

These specimens were found by Mr. H. J. Hauschildt and donated to the National Museum, March 18th, 1908.

6.—*General Remarks on the Age of the Old Dune-rock and associated shell-beds.*

The dune-rock of Warrnambool, like that of Sorrento, owes its origin mainly to the remains of shells, and is therefore almost entirely calcareous. That both of these rocks are far from modern, historically speaking, is proved by the occurrence in the Sorrento dune-rock of the remains of an extinct kangaroo, *Palorchestes*, represented by pelvis, scapula, portions of ribs and a tooth, as recorded by Prof. J. W. Gregory;<sup>1</sup> whilst that at Warrnambool has yielded the footprints of a gigantic bird, probably *Geuyornis*, a contemporary of *Diprotodon* in South Australia.

The Warrnambool dune-rock affords an added interest to geologists, in its relationship to what are probably the latest effusions of volcanic ejectamenta in Victoria, for as we have seen, shell-beds, consisting practically of existing species occur in this locality overlain by volcanic tuffs<sup>2</sup> similar to those of Tower Hill.

1 Proc. Roy. Soc. Victoria, vol. xiv. (n.s.), pt. i., 1901, pp. 139-144. Gregory concludes his paper with these remarks:—"Accordingly the lower exposed part of the Sorrento dunes dates back to the time of extinct kangaroos, the age of which is described as late Pliocene or Lower Pleistocene."

2 Volcanic tuff as defined by Prof. Judd and quoted by Prof. J. W. Gregory is stated to consist of "the finely divided materials, which, owing to the storms of rain which frequently accompany volcanic eruptions," descend in the condition of mud, which flows evenly over the surface of the growing cone and consolidates in beds of very regularly stratified tufa or tuff.

In regard to the plant remains of the tuff-beds, it is worth recording that a block of tuff containing what are probably *Eucalyptus* leaves, was obtained by Mr. Hauschildt<sup>1</sup> some years ago, when the foundations for the Milk Factory at Dennington were being excavated. Data of age derived from fossil floras of so recent a stage are not, however, of much value, seeing that their types are more persistent than those of animals. Thus the tuffs of Mount Gambier have yielded fronds of the Bracken fern (*Pteris aquilina*) and of *Banksia*, practically identical with plants now living in the same locality.

The Hampden tuffs of the Camperdown district, are in all probability of the same age as those of Warrnambool and have covered ancient swamps such as those of the Pejark Marsh. In samples of this ancient mud deposit which were submitted to one of us (F.C.) by Mr. R. H. Walcott, Curator of the Technological Museum, there were found diatomaceous frustules and remains of a species of *Cyperus* indistinguishable from the living *Cyperus lucidus*.

The extinct marsupial bones found on the shores of the crater lakes of the Camperdown district are probably contemporaneous with the tuff beds, as note the opinion of Prof. Sir Baldwin Spencer and Mr. R. H. Walcott regarding those from Lake Colongulac<sup>3</sup>:—  
“No bones have been found in situ as far as we are aware, those found having been picked up on the shores of the lake, but there is no doubt, like those of the Pejark Marsh, that they were originally deposited in a swamp or lagoon which was afterwards buried under the ashes ejected by the neighbouring volcanoes; the bones in this instance being subsequently freed by the breaking up of the old bed and cast upon the shores of the lake.”

#### SUMMARY.

From the foregoing discussion it may be assumed that:—

1.—The shell-bearing beds underlying the volcanic tuffs near Warrnambool belong to the same episode as the older dune-rock accumulations of that locality and Sorrento, and the swamp deposits under the tuffs of the Camperdown district.

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1 This specimen, presented by Mr. Hauschildt, is now in the National Museum and can be seen in the wall-case of the Australian Gallery.

2 Mem. Geol. Surv. Vict., No. 9, 1810. “Geology of the Camperdown and Mount Elephant District.” Grayson and Mahony, p. 6.

3 Proc. Roy. Soc. Victoria, vol. xxiv. (n.s.), pt. I., 1911, p. 114.

2.—That since the old dune-rock and old swamp deposits contain extinct forms of marsupial remains they presumably belong to the early Pleistocene.

3.—The evidence of the shells from beneath the Warrnambool tuffs shows the fauna to have a geologically recent aspect, but with varietal modifications of the species indicating different geographical features from that now prevailing in the locality, a strong estuarine character antedating the re-juvenation of the present river-system. This ancient estuarine feature is further emphasised by the fact of the prevalence of a wide lava-flow of newer basalt extending down to the present shore-line at Port Fairy and beyond, pointing to the infilling of an ancient river delta which, originally of great extent, embraced the Warrnambool-Portland area.

4.—It may therefore be postulated that the volcanic tuffs of the Tower Hill series were ejected between early Pleistocene and fairly modern times, that is, in late Pleistocene or Holocene, or, using European terms, in early prehistoric times. Compared with the more mature physiographic features shown by the newer volcanic lava flows, these tuffs represent one of the last stages of the volcanic outburst in Victoria.